OCR
A Level
Computer Science
H446 – Paper 1

1

Logic gates and truth tables

Unit 8

Boolean Algebra

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OCR

Oxford Cambridge and RSA

An OCR endorsed teaching and learning tool

Objectives

- Construct truth tables for a variety of logic gates

- Be familiar with drawing and interpreting logic gate circuit diagrams involving multiple gates

- Complete a truth table for a given logic gate circuit

- Write a Boolean expression for a given logic gate circuit

- Draw an equivalent logic gate circuit for a given Boolean expression

Binary switches

- Electronic devices can only recognise the presence or absence of a current

- Computers comprise billions of switches which can either be ON or OFF

- These switches can be combined in different ways to create simple circuits called logic gates

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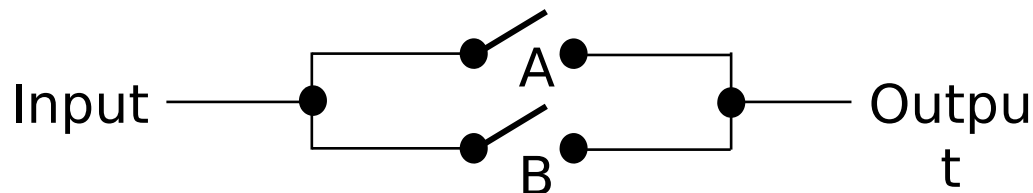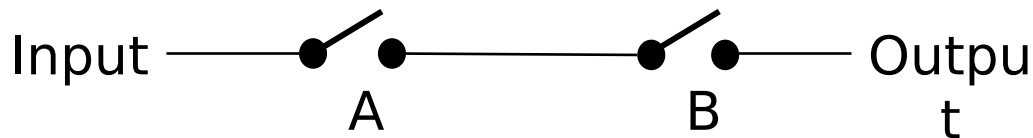
Logic gates

- Electronic logic gates take one or more inputs and produce a single output

- The output can then become the input to the next gate, and so on, to create a complex circuit

  - A number of logic gates are designed to produce different outputs for the various possible combinations of ON or OFF inputs
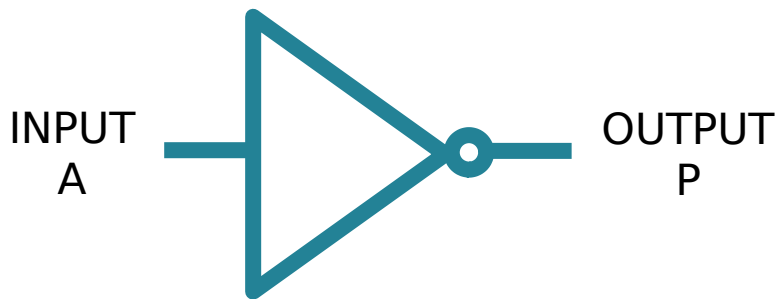
Logic gates

- The four gates studied in this unit are:

  NOT, AND, OR, XOR

- Each of these can be represented by a graphical symbol and a truth table showing the output for each possible input or combination of inputs

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NOT gate

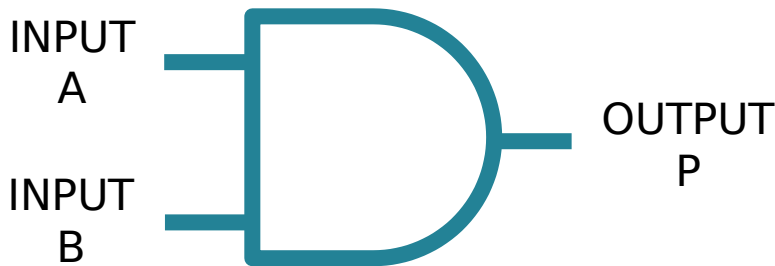- If 0 is input it outputs 1

- If 1 is input it outputs 0

INPUT
A

OUTPUT
P

Logic Diagram

A	P
0	1
1	0

Truth Table

Boolean algebra: P = NOT A **In Boolean notation: P = ¬A**

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AND gate

- If both inputs are 1 then the output is 1

- Otherwise the output is 0

A	B	P
0	0	0
0	1	0
1	0	0
1	1	1

INPUT A

INPUT B

OUTPUT P

Logic Diagram

Truth Table

Boolean algebra: P = A AND B **In Boolean notation: P = A $^\wedge$ B**

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OR gate

- If either input is 1 then the output is 1

- Otherwise the output is 0

A	B	P
0	0	0
0	1	1
1	0	1
1	1	1

INPUT A

INPUT B

OUTPUT P
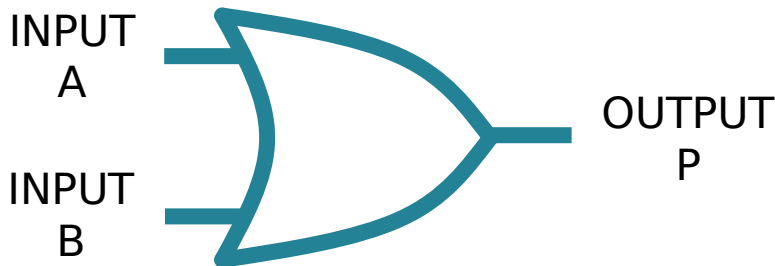
Logic Diagram

Truth Table

Boolean algebra: P = A OR B In Boolean notation: P = A $^\vee$ B

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˅ or ˆ ... which is which?

- Just remember the common notation for two alternatives, a vs. b or just a v b

- Make up some sentences…

  - What are the merits of Economics v English A Level?

  - Advantages of man v machine?
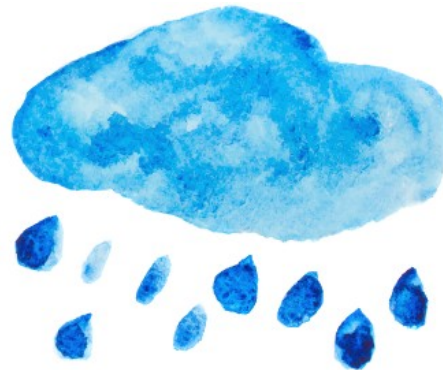
  - Summer v Winter?

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Creating logic circuits

- Multiple logic gates can be connected to produce an output based on multiple inputs
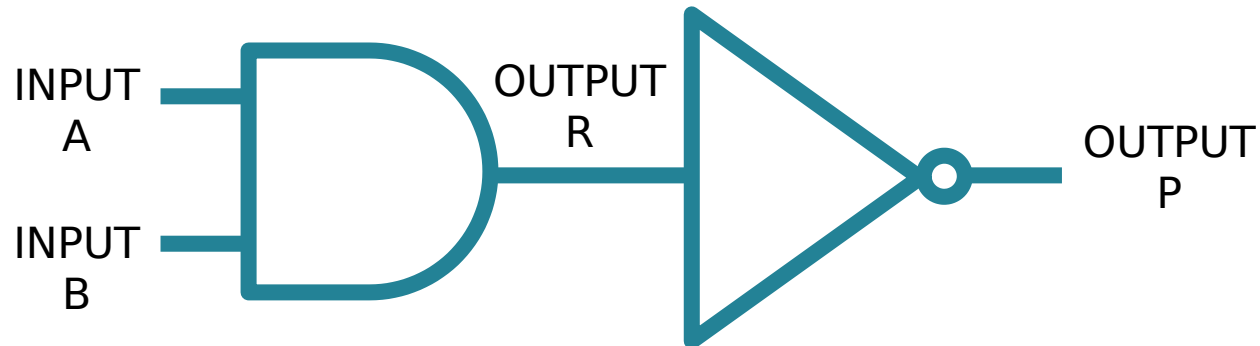
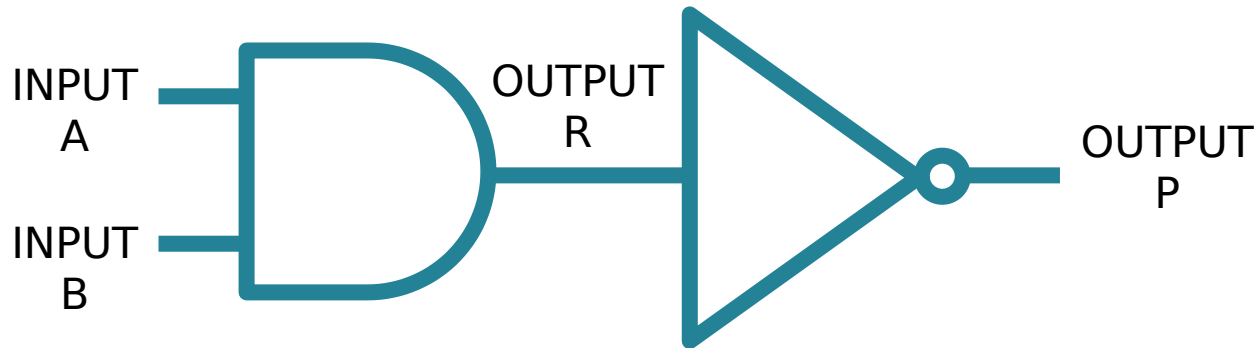| A	B	R = A AND B	P = NOT R
0	0		
0	1		
1	0		
1	1		

Boolean algebra:
P = NOT (A AND B)

In Boolean notation:
P = ¬(A $^\wedge$ B)

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Creating logic circuits

- Multiple logic gates can be connected to produce an output based on multiple inputs
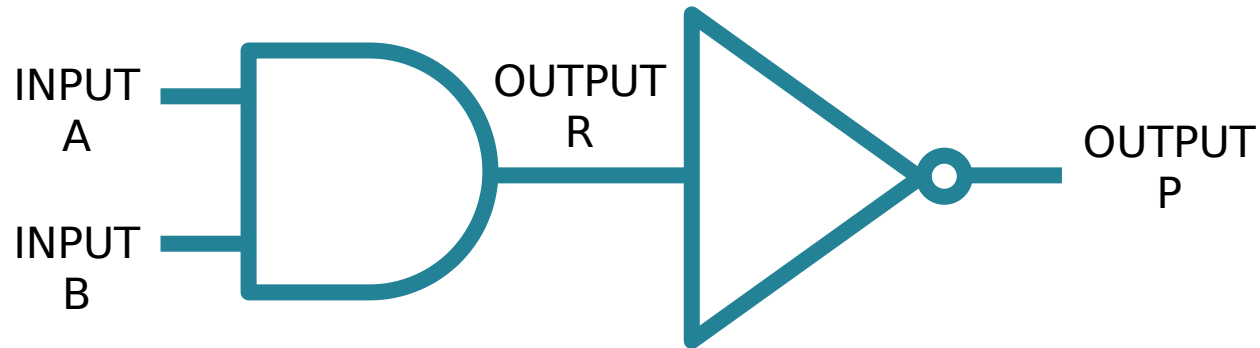
A	B	R = A AND B	P = NOT R
0	0	**0**	
0	1	**0**	
1	0	**0**	
1	1	**1**	

Boolean algebra:
P = NOT (A AND B)

In Boolean notation:
P = ¬(A ^ B)

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Creating logic circuits

- Multiple logic gates can be connected to produce an output based on multiple inputs

A	B	R = A AND B	P = NOT R
0	0	**0**	1
0	1	**0**	1
1	0	**0**	1
1	1	**1**	0

Boolean algebra:
P = NOT (A AND B)

In Boolean notation:
P = ¬(A $^\wedge$ B)

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Increasing the number of inputs

- With three inputs, how many possible combinations of 0 and 1 are there?
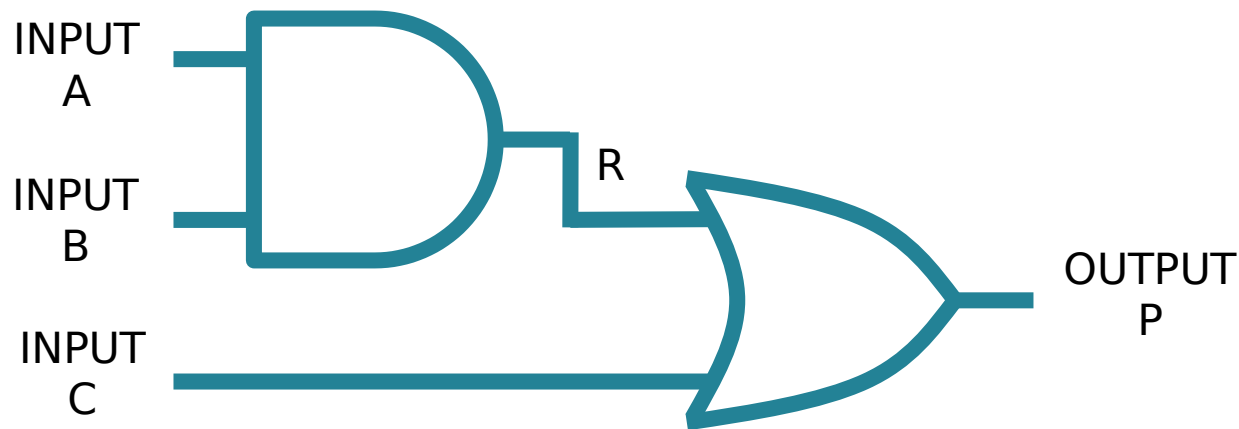
Boolean algebra:
P = (A AND B) OR C

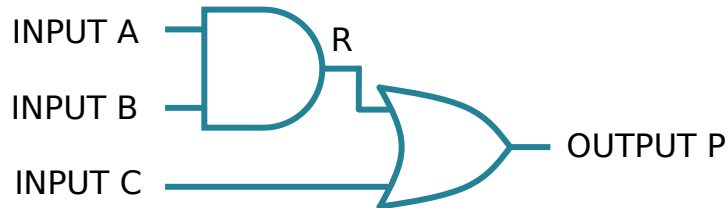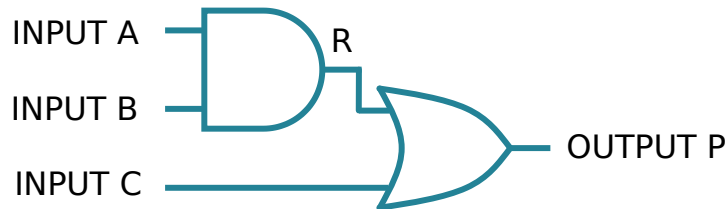**In Boolean notation:**
$$P = (A \wedge B) \vee C$$

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Combining logic gates
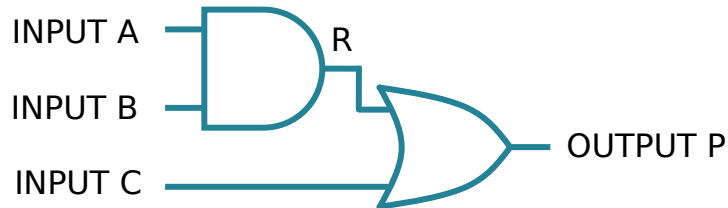
A	B	C	R = A AND B	P = R OR C
0	0	0		
0				
0				
0				
1				
1				
1				
1				

Boolean algebra:
P = (A AND B) OR C

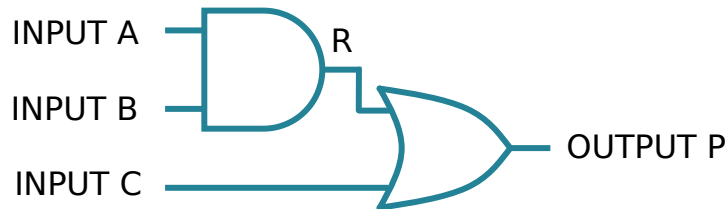**In Boolean notation:**
P = (A $^\wedge$ B) $^\vee$ C

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Combining logic gates
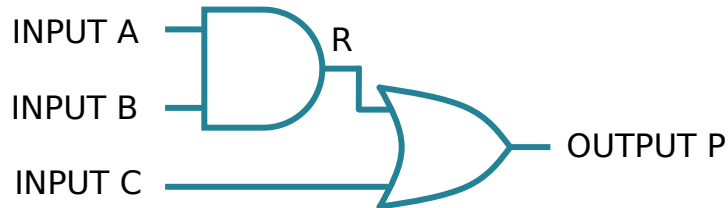
A	B	C	R = A AND B	P = R OR C
0	0	0		
0	0			
0	1			
0	1			
1	0			
1	0			
1	1			
1	1			

Boolean algebra:
P = (A AND B) OR C

In Boolean notation:
P = (A $^\wedge$ B) $^\vee$ C

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Combining logic gates


A	B	C	R = A AND B	P = R OR C
0	0	0		
0	0	1		
0	1	0		
0	1	1		
1	0	0		
1	0	1		
1	1	0		
1	1	1		

Boolean algebra:
P = (A AND B) OR C

In Boolean notation:
P = (A $\wedge$ B) $\vee$ C

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Combining logic gates

A	B	C	R = A AND B	P = R OR C
0	0	0	0	
0	0	1	0	
0	1	0	0	
0	1	1	0	
1	0	0	0	
1	0	1	0	
1	1	0	1	
1	1	1	1	

Boolean algebra:
P = (A AND B) OR C
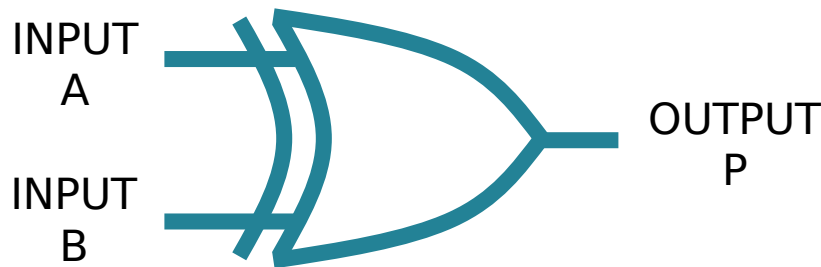
In Boolean notation:
P = (A $^\wedge$ B) $^\vee$ C

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Combining logic gates

A	B	C	R = A AND B	P = R OR C
0	0	0	0	0
0	0	1	0	1
0	1	0	0	0
0	1	1	0	1
1	0	0	0	0
1	0	1	0	1
1	1	0	1	1
1	1	1	1	1

Boolean algebra:
P = (A AND B) OR C

In Boolean notation:
P = (A $^\wedge$ B) $^\vee$ C

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Worksheet 1

- Now try the questions in **Task 1**

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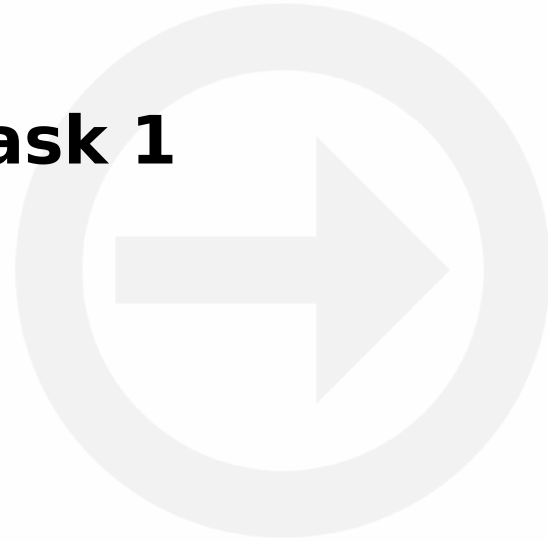
XOR (Exclusive OR) gate

- If one, but not both, of the inputs is 1, the output is 1

- Otherwise the output is 0

A	B	P
0	0	0
0	1	1
1	0	1
1	1	0

Logic Diagram   **Truth Table**

Boolean algebra: P = A XOR B Boolean notation: P = A ⩝ B

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Worksheet 1

- Now try the questions in **Task 2**
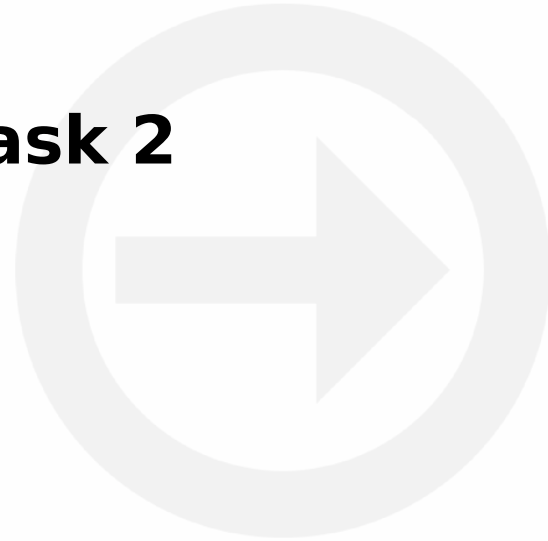
Plenary

- There are four logic gates that you need to be familiar with

- Be sure you can :

  - Write truth tables for each of them

  - Write a Boolean expression for a given logic gate circuit

  - Draw an equivalent logic gate circuit for a given Boolean expression

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